

Great Lakes Water Levels and Coastal Impacts

MAY 2021

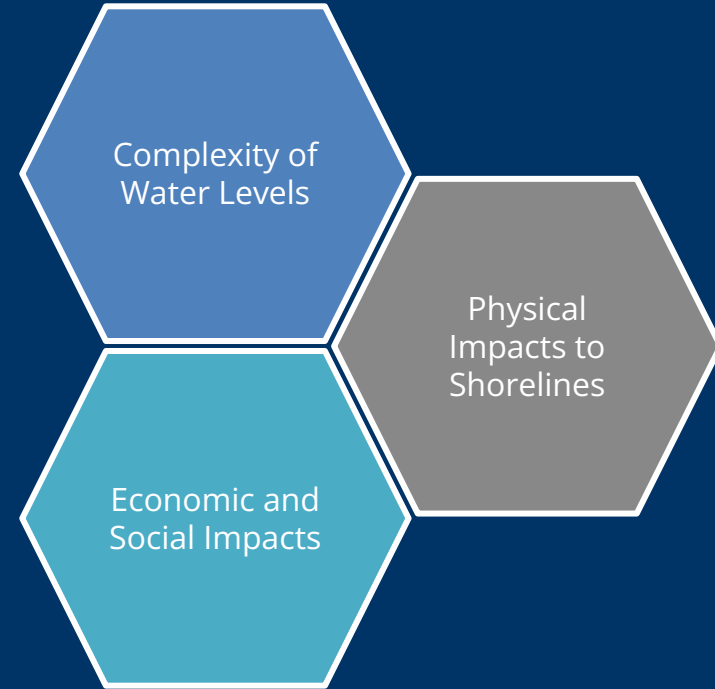
Brandon Krumwiede

Physical Scientist / Great Lakes Regional Geospatial Coordinator

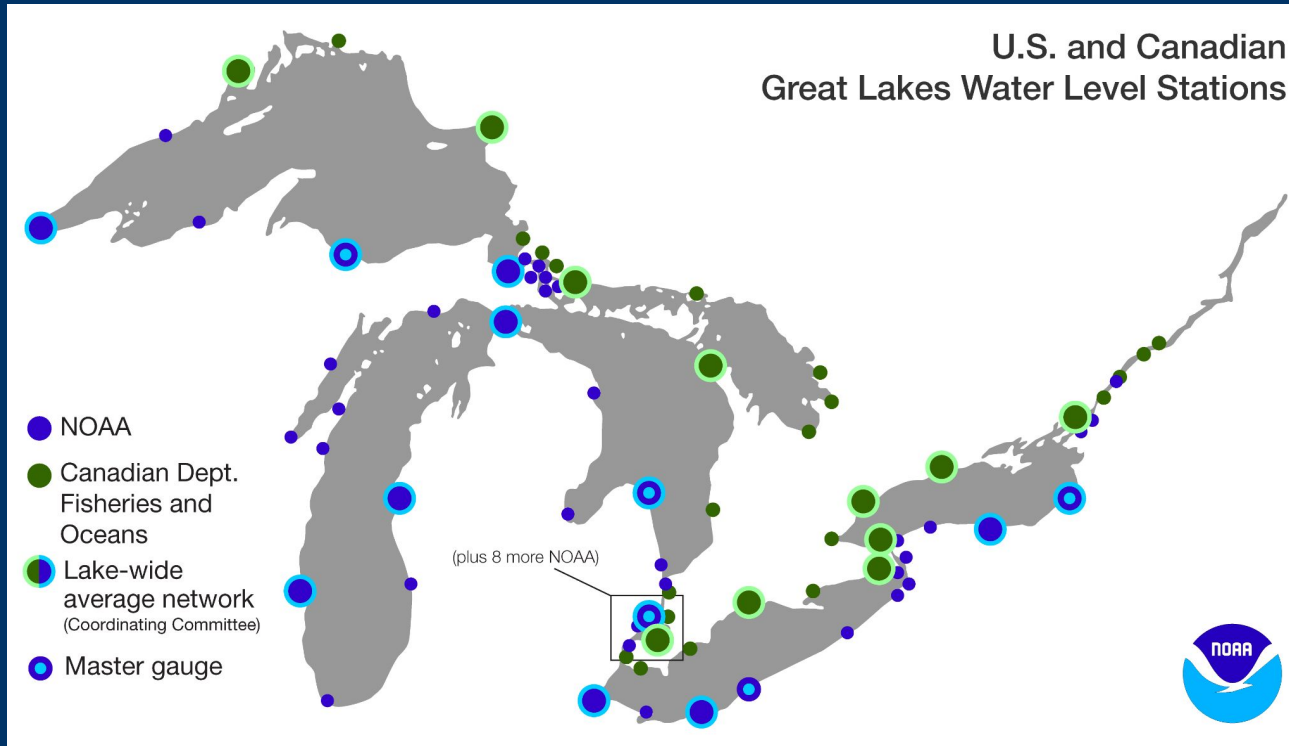
NOAA Office for Coastal Management

The Coastal Challenge

- Shorelines are naturally dynamic and complex due to the interface between land, water, and air
- Coastal management refers to actions taken to keep residents safe, the economy sound, and natural resources functioning
- Work towards protecting coastal communities and improving resiliency



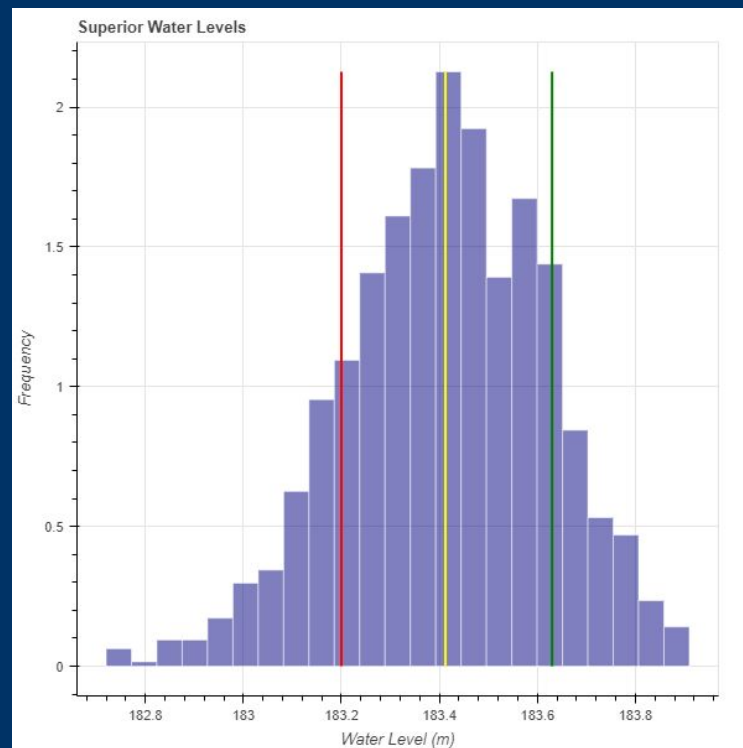
Complexity of Water Levels



Complexity of Water Levels: Superior

Based on Lakewide Monthly Average Values:
Minimum Water Level: 182.72 meters / 599.47 feet
(April 1926)
Maximum Water Level: 183.91 meters / 603.37 feet
(October 1985)
Difference: 1.19 meters / 3.9 feet

- Low Water Datum
- Long Term Average
- Water Level December 2020



Complexity of Water Levels: Superior

Based on Lakewide Monthly Average Values:

Minimum Water Level: 182.72 meters / 599.47 feet (April 1926)

Maximum Water Level: 183.91 meters / 603.37 feet (October 1985)

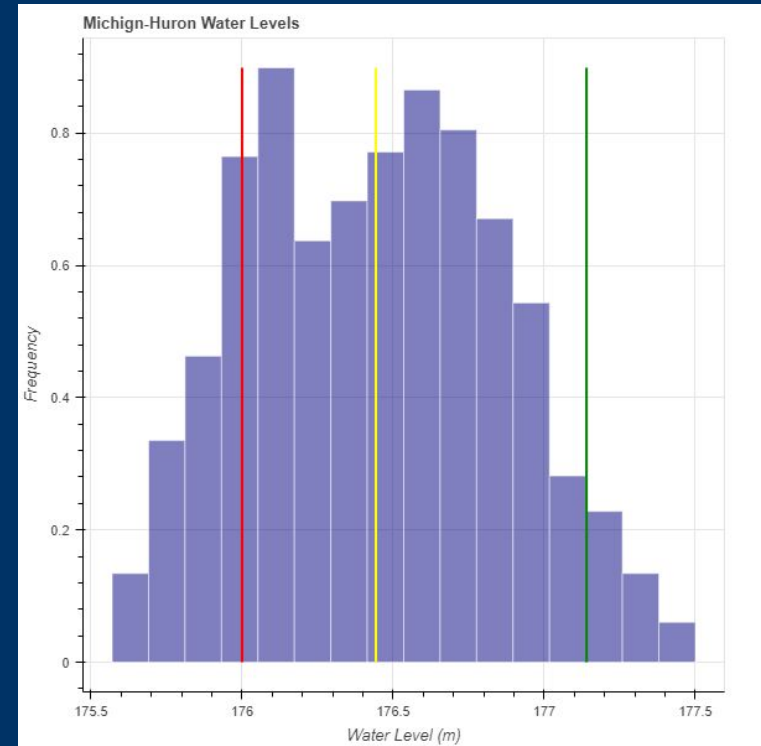
Difference: 1.19 meters / 3.9 feet

	ID	LWD (ft)	Max (ft)	Date	Min (ft)	Date	Absolute Range (ft)	Above LWD (ft)	Below LWD (ft)
Superior							5.97	3.65	-2.32
Point Iroquois, MI	9099004	601.1	604.46	10/4/2018	598.78	5/30/2011	5.68	3.36	-2.32
Duluth, MN	9099064	601.1	604.75	10/21/2019	598.98	2/18/2011	5.77	3.65	-2.12
Marquette C.G., MI	9099018	601.1	604.06	9/30/2019	599.17	3/22/2007	4.89	2.96	-1.93
Grand Marais, MN	9099090	601.1	604.01	1/30/2019	599.28	3/19/2007	4.73	2.91	-1.82
Ontonagon, MI	9099044	601.1	604.13	7/21/2016	599.63	3/19/2007	4.5	3.03	-1.47

Complexity of Water Levels: Michigan-Huron

Based on Lakewide Monthly Average Values:
Minimum Water Level: 175.57 meters / 576.02 feet
(January 2013)
Maximum Water Level: 177.5 meters / 582.35 feet
(October 1986)
Difference: 1.93 meters / 6.33 feet

- Low Water Datum
- Long Term Average
- Water Level December 2020



Complexity of Water Levels: Michigan-Huron

Based on Lakewide Monthly Average Values:

Minimum Water Level: 175.57 meters / 576.02 feet (January 2013)

Maximum Water Level: 177.5 meters / 582.35 feet (October 1986)

Difference: 1.93 meters / 6.33 feet

	ID	LWD (ft)	Max (ft)	Date	Min (ft)	Date	Absolute Range (ft)	Above LWD (ft)	Below LWD (ft)
Michigan							8.99	5.99	-3.00
Ludington, MI	9087023	577.5	583.48	6/10/2020	575.49	4/10/2013	7.99	5.98	-2.01
Milwaukee, WI	9087057	577.5	583.16	8/10/2020	575.34	1/18/2013	7.82	5.66	-2.16
Green Bay East, WI	9087077	577.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Holland, MI	9087031	577.5	583.01	4/29/2020	575.34	1/18/2013	7.67	5.51	-2.16
Kewaunee, WI	9087068	577.5	583.18	12/1/2019	575.26	1/13/2013	7.92	5.68	-2.24
Menominee, MI	9087088	577.5	583.24	6/10/2020	574.84	1/20/2013	8.4	5.74	-2.66
Calumet Harbor, IL	9087044	577.5	583.49	5/31/1998	574.50	12/23/2007	8.99	5.99	-3.00
Sturgeon Bay, WI	9087072	577.5	582.95	6/9/2020	575.43	1/20/2013	7.52	5.45	-2.07
Port Inland, MI	9087096	577.5	583.30	6/10/2020	575.09	1/17/2013	8.21	5.80	-2.41

Complexity of Water Levels: Michigan-Huron

Based on Lakewide Monthly Average Values:

Minimum Water Level: 175.57 meters / 576.02 feet (January 2013)

Maximum Water Level: 177.5 meters / 582.35 feet (October 1986)

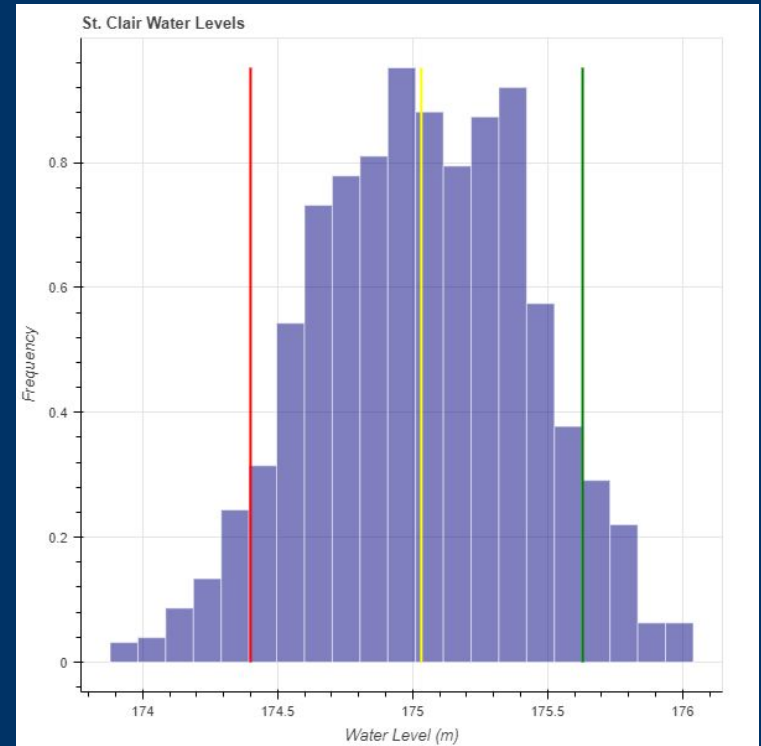
Difference: 1.93 meters / 6.33 feet

	ID	LWD (ft)	Max (ft)	Date	Min (ft)	Date	Absolute Range (ft)	Above LWD (ft)	Below LWD (ft)
Huron							11.06	6.53	-4.53
Lakeport, MI	9075002	577.5	583.47	7/19/2020	574.72	1/30/2008	8.75	5.97	-2.78
Alpena, MI	9075065	577.5	583.04	7/20/2019	574.45	1/30/2008	8.59	5.54	-3.05
Harbor Beach, MI	9075014	577.5	582.89	7/19/2020	575.36	1/30/2008	7.53	5.39	-2.14
Mackinaw City, MI	9075080	577.5	582.81	7/19/2020	575.14	1/20/2013	7.67	5.31	-2.36
Essexville, MI	9075035	577.5	584.03	1/11/2020	572.97	12/23/2007	11.06	6.53	-4.53
De Tour Village, MI	9075099	577.5	582.58	1/10/2020	574.97	12/21/2012	7.61	5.08	-2.53

Complexity of Water Levels: St. Clair

Based on Lakewide Monthly Average Values:
Minimum Water Level: 173.88 meters / 570.47 feet
(January 1936)
Maximum Water Level: 176.04 meters / 577.55 feet
(July 2019)
Difference: 2.16 meters / 7.08 feet

- Low Water Datum
- Long Term Average
- Water Level December 2020



Complexity of Water Levels: St. Clair

Based on Lakewide Monthly Average Values:

Minimum Water Level: 173.88 meters / 570.47 feet (January 1936)

Maximum Water Level: 176.04 meters / 577.55 feet (July 2019)

Difference: 2.16 meters / 7.08 feet

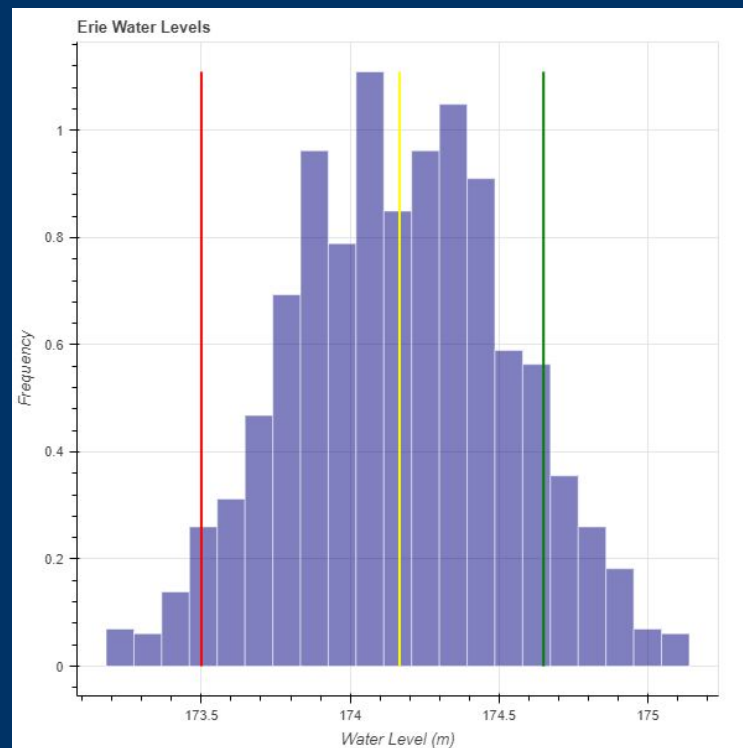
	ID	LWD (ft)	Max (ft)	Date	Min (ft)	Date	Absolute Range (ft)	Above LWD (ft)	Below LWD (ft)
St. Clair							6.71	5.54	-1.17
St. Clair Shores, MI	9034052	572.3	577.84	5/19/2020	571.13	1/20/2013	6.71	5.54	-1.17

* Note the difference in values for absolute range

Complexity of Water Levels: Erie

Based on Lakewide Monthly Average Values:
Minimum Water Level: 173.18 meters / 568.17 feet
(February 1935)
Maximum Water Level: 175.14 meters / 574.6 feet
(June 2019)
Difference: 1.96 meters / 6.43 feet

- Low Water Datum
- Long Term Average
- Water Level December 2020



Complexity of Water Levels: Erie

Based on Lakewide Monthly Average Values:

Minimum Water Level: 173.18 meters / 568.17 feet (February 1935)

Maximum Water Level: 175.14 meters / 574.6 feet (June 2019)

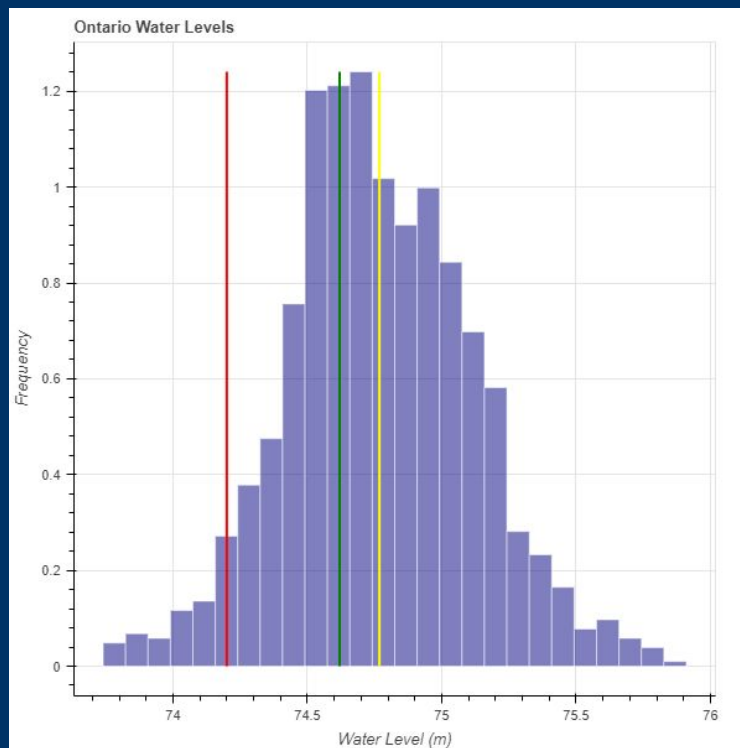
Difference: 1.96 meters / 6.43 feet

	ID	LWD (ft)	Max (ft)	Date	Min (ft)	Date	Absolute Range (ft)	Above LWD (ft)	Below LWD (ft)
Erie							17.43	11.05	-6.38
Buffalo, NY	9063020	569.2	580.25	1/30/2008	567.00	2/2/2011	13.25	11.05	-2.20
Fairport, OH	9063053	569.2	575.10	7/2/2019	568.80	1/30/2008	6.3	5.90	-0.40
Toledo, OH	9063085	569.2	576.83	4/15/2018	562.82	1/30/2008	14.01	7.63	-6.38
Sturgeon Point, NY	9063028	569.2	578.59	1/30/2008	567.37	2/2/2011	11.22	9.39	-1.83
Cleveland, OH	9063063	569.2	575.33	7/10/2020	567.77	1/30/2008	7.56	6.13	-1.43
Fermi Power Plant, MI	9063090	569.2	576.40	4/9/1998	564.05	11/13/2003	12.35	7.20	-5.15
Erie, PA	9063038	569.2	576.20	4/13/2020	568.30	2/2/2011	7.9	7.00	-0.90
Marblehead, OH	9063079	569.2	575.46	5/18/2020	565.45	1/30/2008	10.01	6.26	-3.75

Complexity of Water Levels: Ontario

Based on Lakewide Monthly Average Values:
Minimum Water Level: 73.74 meters / 241.92 feet
(December 1934)
Maximum Water Level: 75.91 meters / 249.04 feet
(June 2019)
Difference: 2.17 meters / 7.12 feet

- Low Water Datum
- Long Term Average
- Water Level December 2020



Complexity of Water Levels: Ontario

Based on Lakewide Monthly Average Values:

Minimum Water Level: 73.74 meters / 241.92 feet (December 1934)

Maximum Water Level: 75.91 meters / 249.04 feet (June 2019)

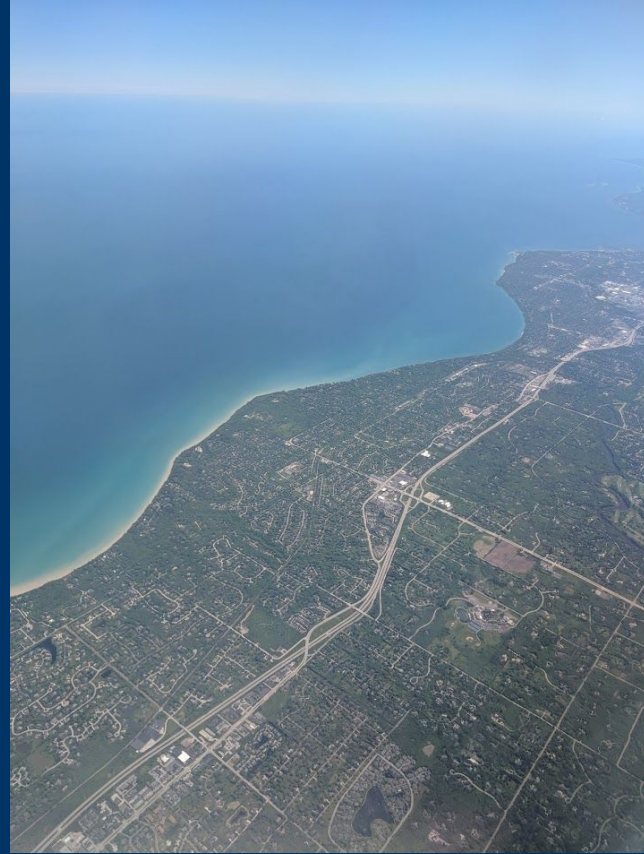
Difference: 2.17 meters / 7.12 feet

	ID	LWD (ft)	Max (ft)	Date	Min (ft)	Date	Absolute Range (ft)	Above LWD (ft)	Below LWD (ft)
Ontario							6.50	6.04	-0.46
Cape Vincent, NY	9052000	243.3	249.33	6/11/2019	242.84	1/2/1999	6.49	6.03	-0.46
Olcott, NY	9052076	243.3	249.30	6/4/2019	243.24	11/27/2007	6.06	6.00	-0.06
Oswego, NY	9052030	243.3	249.34	5/25/2019	243.06	1/3/1999	6.28	6.04	-0.24
Rochester, NY	9052058	243.3	249.28	5/29/2019	243.10	1/3/1999	6.18	5.98	-0.20

* Note the difference in values for absolute range

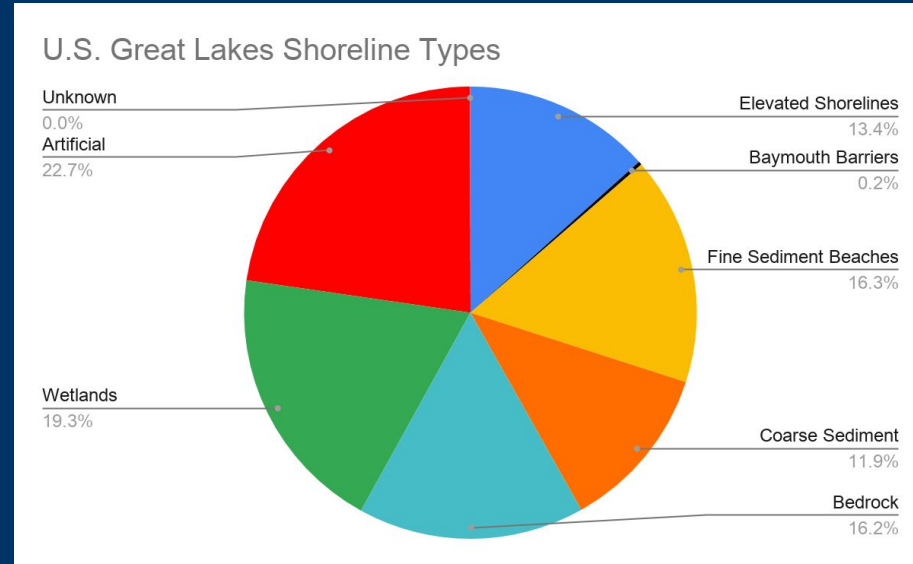
Physical Impacts

- Coastal Flooding
- Shoreline Erosion/Deposition
- Increased sediment transport in the littoral zone
- Alterations to stream and river mouths
- Loss of coastal terrestrial and wetland habitat
- Increased impacts when storms move through



U.S. Great Lakes Shoreline

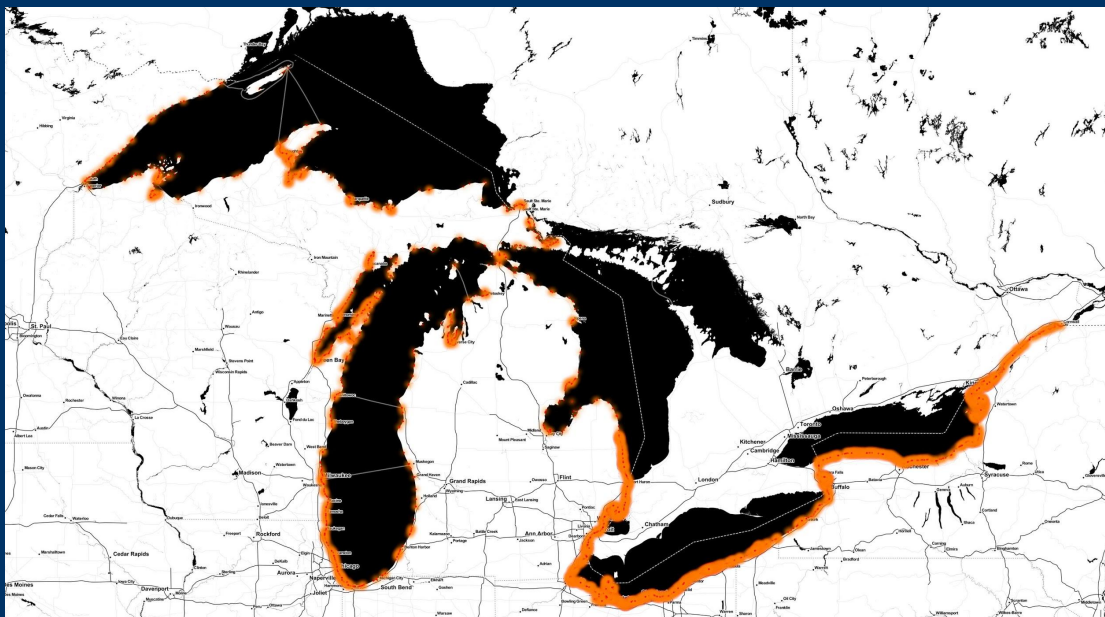
Shoreline Type	Percentage
Elevated Shorelines (Bluffs, Banks, Low Plains)	13.4%
Baymouth Barriers	0.2%
Fine Sediment Beaches	16.3%
Coarse Sediment Beaches	11.9%
Bedrock	16.2%
Wetlands	19.3%
Artificial	22.7%
Unknown	0.0%



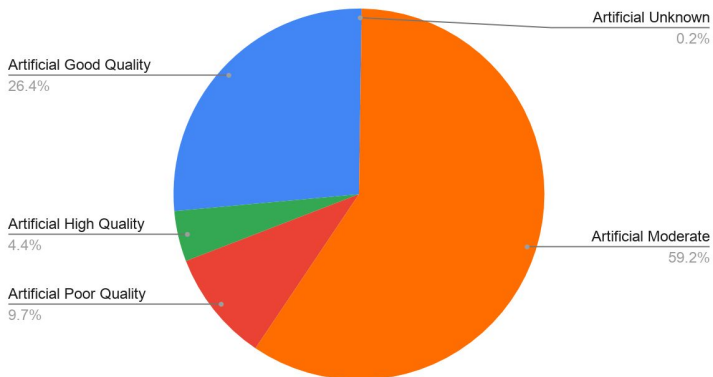
Source: Summarized from 2019 US Great Lakes Hardened Shorelines Classification Dataset

U.S. Great Lakes Shoreline: Artificial/Hardened

Over 1/5 of the U.S. Great Lakes shoreline is classed as artificial or hardened by coastal infrastructure



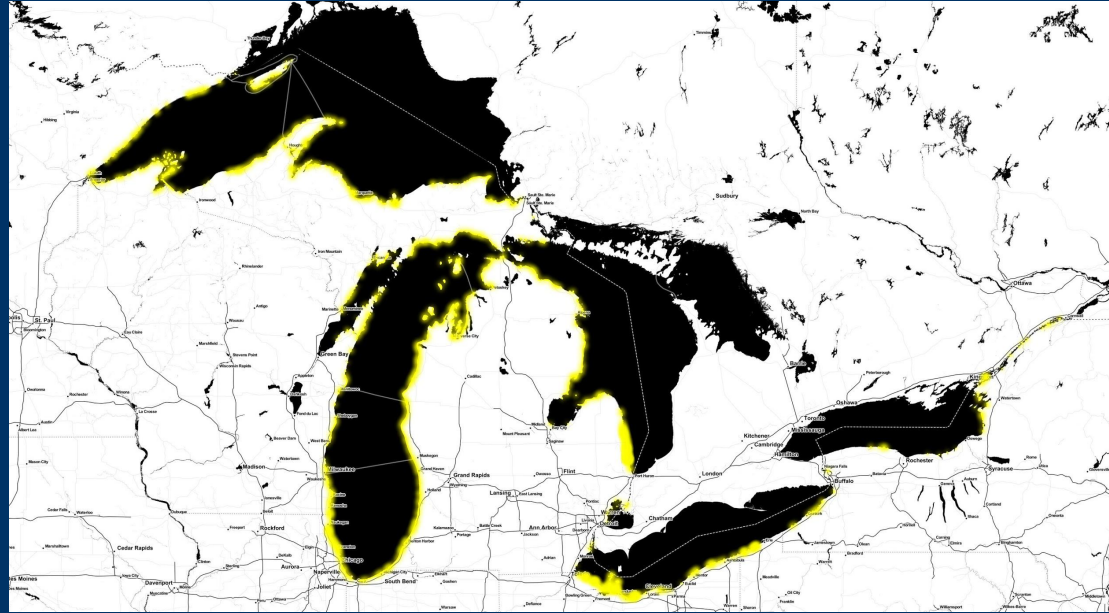
U.S. Great Lakes Artificial Shoreline Condition



Source: 2019 US Great Lakes Hardened Shorelines Classification Dataset

U.S. Great Lakes Shoreline: Beaches

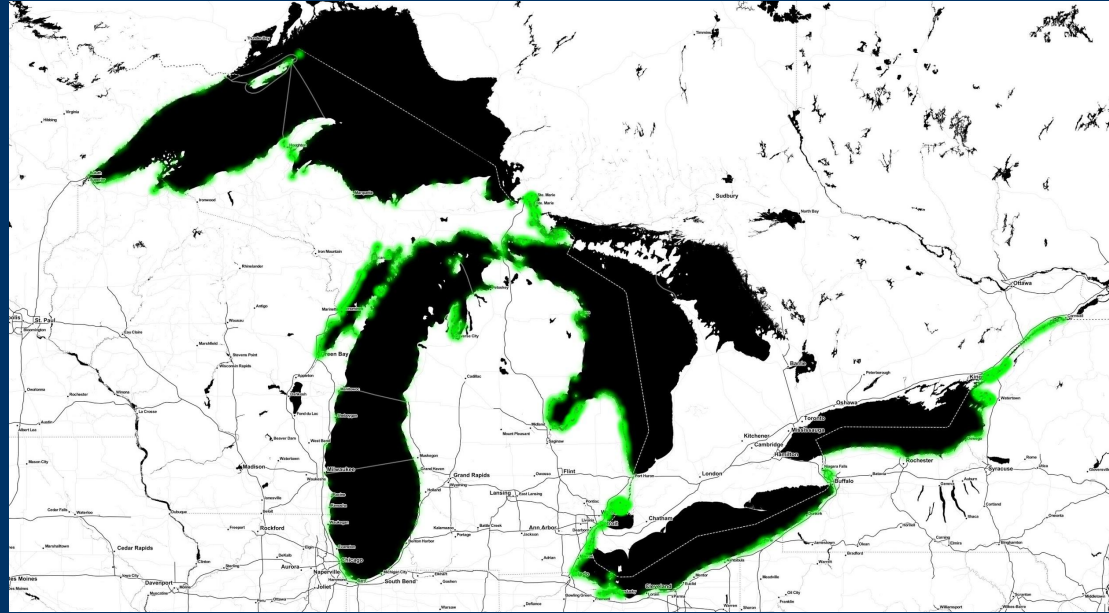
- Over 16% of the U.S. Great Lakes shoreline is classed as fine sediment beaches
- High concentration in Lake Michigan
- Highly dynamic and susceptible to changes in water levels, storms and longshore (littoral) drift



Source: 2019 US Great Lakes Hardened Shorelines Classification Dataset

U.S. Great Lakes Shoreline: Wetlands

- Almost 1/5 of the U.S. Great Lakes shorelines are classed as coastal and river mouth wetlands
- These wetland extents are dynamic in response to changes in water levels



Source: 2019 US Great Lakes Hardened Shorelines Classification Dataset

Illinois Beach State Park

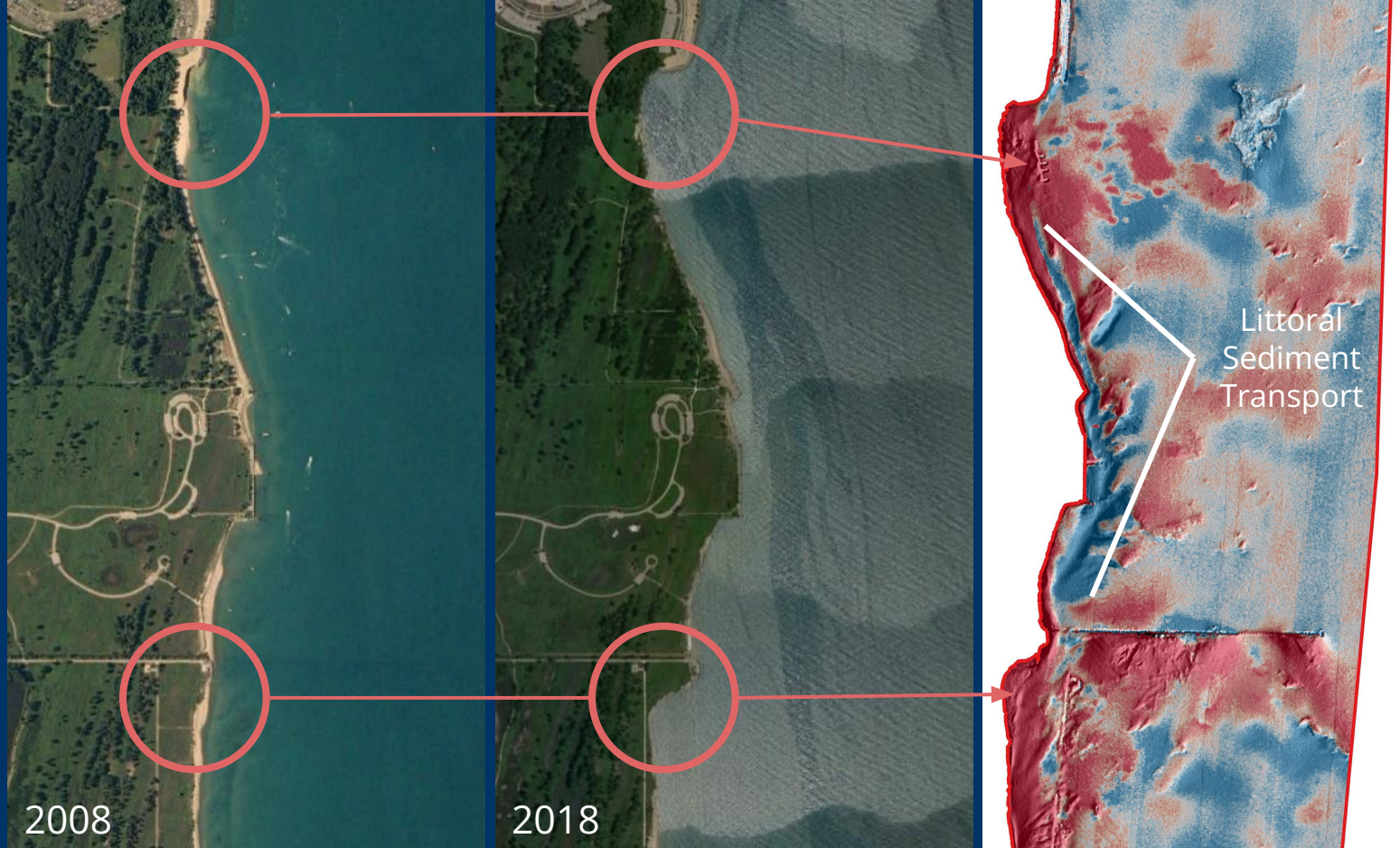
Coastal Erosion

Impact to coastal wetlands and habitat

Littoral sediment transport

Red - erosion

Blue - deposition



Economic and Social Impacts

- Damage to coastal infrastructure
- Flooded marinas and docks
- Hazards to navigation
- Shrinking or alteration of beaches for recreational use
- Damage and loss of private property
- Solastalgia - distress caused by environmental change^{*}

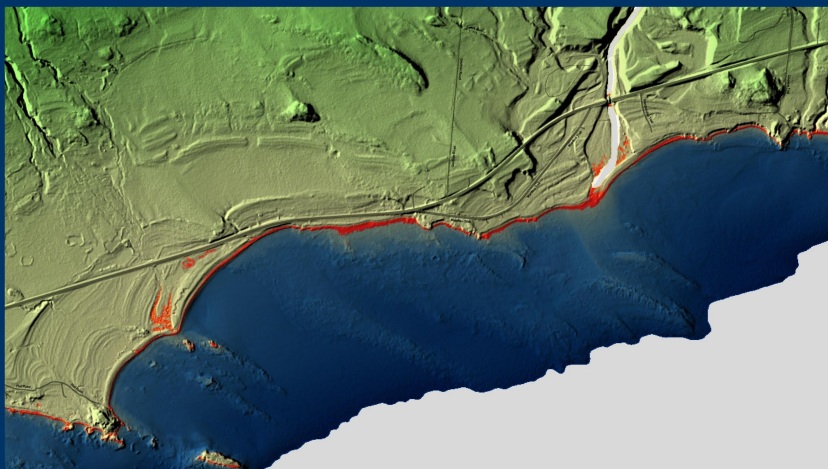


^{*}Albrecht, Glenn (2007). "Solastalgia: the distress caused by environmental change". *Australasian Psychiatry*. **15**: S95-S98. doi:10.1080/10398560701701288. PMID 18027145

Digital Coast

Data, Tools, Trainings, and Resources

<https://coast.noaa.gov/digitalcoast/>



LAKE LEVEL VIEWER
United States Great Lakes

Choose a Lake to Explore

Lake Superior Lake Michigan Lake Huron Lake Erie Lake Ontario

Adaptation Strategies

Office for Coastal Management
DIGITALCOAST

ABOUT DATA TOOLS TRAINING TOPICS STORES

Adaptation Strategies

Coastal communities are striving to find new ways to protect the built and natural environment from powerful storms and frequent flooding. Provided below are examples of Digital Coast resources commonly used by coastal officials to create or improve adaptation strategies.

Getting Started

- Training: Adaptation Planning for Coastal Communities [View](#)
- Training: Introducing Green Infrastructure [View](#)
- Publication: Adapting to Climate Change [View](#)

Great Lakes Coastal Zone Management Programs





Thank You!

Brandon Krumwiede GCP-R, GISP
brandon.krumwiede@noaa.gov
(320) 290-1381
@bkgeospatial